RECOMMENDATION ITU-R SF.1707

Methods to facilitate the implementation of large numbers of earth stations in the FSS in areas where terrestrial services are also deployed

(2005)

Scope

This Recommendation provides methods and means to facilitate the implementation of large numbers of earth stations operating in the fixed-satelllite service (FSS) in areas where terrestrial services are also deployed. It includes examples for the deployment of a large number of FSS earth stations, guidance for an agreed interference calculation to facilitate implementation of such large numbers of earth stations, and an example of how to develop a single transmit and a single receive coordination distance for consideration as a means to ease bilateral agreements for a given geographical area.

The ITU Radiocommunication Assembly,

considering

a) that an increasing number of fixed-satellite service (FSS) network applications, operating in certain FSS bands, plan to deploy large numbers of earth stations;

b) that these FSS networks are subject to coordination under various provisions of the ITU Radio Regulations (RR);

c) that in some frequency bands above 17 GHz, allocated to the FSS, administrations may consider various options to facilitate establishing FSS systems which will provide broadband services to a large number of earth stations;

d) that the deployment of large numbers of FSS earth stations is most suitable in frequency bands not shared with terrestrial services in the same geographic area, but that in some bands there will be sharing between FSS earth stations and terrestrial stations in some areas;

e) that there may be a need to facilitate the implementation of such services involving the coordination/registration of large numbers of FSS earth stations in areas where terrestrial services are also deployed in the same frequency band;

f) that a number of FSS systems with types of earth stations and characteristics other than those used by systems with large numbers of earth stations have already been brought into use or are planned to be brought into use,

noting

a) that, in shared bands, the use of interference mitigation techniques by the fixed service (FS) and FSS may reduce the number of cases where interference between FS and FSS occurs,

recommends

1 that the elements in Annex 2 may be used as guidance for an agreed interference calculation which may be used to facilitate the implementation of large numbers of earth stations and terrestrial FS stations in the same band for the cases described in Annex 1 (see Notes 1 and 2);

2 that a single transmit and a single receive coordination distance for the case of coordination of large numbers of similar earth stations (see Note 3) could be considered for use by administrations as a means to facilitate bilateral agreements for a given geographical area;

3 that the following Notes should be considered as a part of this Recommendation.

NOTE 1 – The examples in Annex 1 make use of databases containing technical and geographical information for FSS earth stations and FS stations, and appropriate agreed-upon interference computation programs, to allow the guidelines to be implemented.

NOTE 2 – In addition to the examples in Annex 1, FSS systems communicated to the Radiocommunication Bureau which have been coordinated on a site-by-site basis, with types of earth stations and characteristics other than those used by high-density systems, should also be taken into account.

NOTE 3 – Annex 3 provides an example of a parametric analysis using RR Appendix 7 for development of a single coordination distance applicable to a particular geographic area. The calculations use a representative set of earth station characteristics. The results of this analysis suggest that it may be possible to arrive at a single transmit and single receive coordination distance beyond which coordination between FSS earth stations and FS stations would not be required. Such a coordination distance could be used to reduce the number of calculations required under a simplified coordination methodology. The distance will vary depending on frequency, station characteristics, and the particular geographic area. It is noted that administrations have to agree on earth station characteristics to be considered for each case of coordination.

NOTE 4 – Given that the methods considered in this Recommendation rely upon databases containing the specific locations of FS and FSS stations, this Recommendation is not meant to apply to those cases where the FS has been authorized on an area basis.

Annex 1

Examples for the deployment of large numbers of FSS earth stations

1 Introduction

In recent years, it has been recognized that a number of FSS systems currently being planned or developed will likely encompass a very large number of earth stations. FSS systems will find ideal conditions for deployment in bands where there is no FS allocation since in these bands no coordination between FSS earth stations and FS stations is required. However, many FSS systems are planned for deployment in bands where there is an FS allocation in the ITU Table of Frequency Allocations. These FSS networks are subject to coordination under various provisions of the RR.

The objective of this Annex is to provide descriptive examples of how to ease the regulatory procedures associated with the deployment of large numbers of earth stations through a simplification in the coordination/registration process. In addition, this Annex provides an example of the methodology that can readily be adapted to different specific conditions.

Three different deployments of large numbers of earth stations are addressed:

1. national coordination/registration;
2. coordination/registration within a bilateral agreement between two administrations;
3. international coordination/registration in accordance with the RR.

For each of these three deployments, there are two interference situations to be considered: interference from an FS station to a receive FSS earth station; and interference from a transmit FSS earth station to an FS station.

2 Frequency bands

As noted above, the deployment of large numbers of earth stations in FSS frequency allocations can best be carried out in bands that are not shared with terrestrial services. The methodology presented here is intended to apply to bands shared with the FS, e.g. in various frequency bands allocated to the FSS.

An examination of FSS allocations indicates that some are shared with terrestrial services, in particular the FS, and some allocations are not.

2.1 Bands not shared with FS

In the case where large numbers of FSS earth stations operate in bands not shared with FS these bands are still shared with other FSS systems, so FSS earth stations with other types of technical characteristics must continue to be accommodated. Since such bands are not shared on a co-primary basis with FS, no issues arise with respect to individual site coordination of FSS earth stations.

2.2 Bands shared with FS

It is expected that deployment of large numbers of FSS earth stations will take place in various bands shared with the FS.

To deploy large numbers of FSS earth stations in bands shared with terrestrial services requires techniques and methods that ensure that mutual unacceptable interference is avoided. In areas where there is already heavy deployment of FS links, it may become difficult to site FSS earth stations. In any case, the methodology described in § 3 of this Annex addresses the situation where the band is shared with FS.

3 Deployment of FSS earth stations

This section describes a methodology to facilitate implementation of large numbers of earth stations associated with FSS systems. Administrations and/or satellite operators will need to take necessary steps to identify the frequency bands and associated geographical areas where this method would be implemented.

3.1 Deployment of receive FSS earth stations in country "A"

3.1.1 Coordination/registration within individual countries

This section provides an example of simplified coordination/registration for the case where FS stations exist in country A, or there are plans for deploying them in the future, and that administration wishes to ensure protection of its receive FSS earth stations. This case includes four steps:

Step 1: Identification of FS transmitting stations: The identification of FS stations that can potentially cause interference to the FSS earth station would be based on a search of a particular administration's database containing details (see Annex 2) of such transmit FS stations and on application of an interference computation program.

Step 2: Detailed national coordination, if required: If the FSS operator finds, upon applying an agreed interference computation program or other desired interference analysis tools, that potential unacceptable interference may be caused to the FSS earth station by the FS stations identified in Step 1, then detailed coordination with the operator(s) of the potentially interfering FS station(s) must be conducted. If operation of the receive FSS earth station at a location under consideration or at any other suitable location is not feasible, no FSS service can be provided to that location in that frequency band.

Step 3: Registration of the new FSS earth station: Registration of the new FSS earth station (i.e. addition of this earth station to the national database of receive earth stations) in order to ensure that future FS stations will take it into consideration can only occur upon successfully completing application of the agreed interference computation program, or upon successful conclusion of detailed coordination.

Step 4: Future protection of the receive FSS earth station: As new transmit FS stations are to be deployed, the FS operator, based on a pre-agreed interference computation program, determines whether there is potential for causing unacceptable interference to any of the FSS receive earth stations in the database of a particular administration.

An example of how the four steps in the methodology could be implemented is given in Attachment 1 to Annex 1.

This national coordination/registration is feasible only if there is available a reliable database (all transmit FS stations and receive FSS earth stations in the band under consideration) and a pre-agreed interference computation program to determine whether the transmit FS station can be deployed.

In Step 1 of the process, the FSS operator may elect to use the agreed interference computation program that is required for Step 4, however this is not mandatory. The FSS operator has the freedom to be more or less conservative at this stage of the process because, if unacceptable interference caused by any of the pre-existing FS stations does occur after the earth station is installed, the responsibility for any measures required to mitigate interference problems from these pre-existing FS stations lies entirely with the FSS operator.

On the other hand, in Step 4 agreement on an interference computation program becomes essential. If, after an FSS earth station is registered, unacceptable interference from an FS station subsequently deployed is observed, it is critical to determine the technical basis on which the FS station was deployed. This can only be done if an interference computation is agreed. If the FS station was installed after verifying that the agreed interference computation was successfully employed, the interfered with FSS operator has the responsibility to remedy the situation. On the other hand, if the FS station was deployed in violation of the agreed interference computation, the FS station operator would need to immediately take steps to reduce the interference to levels that are compliant with the agreed computation program. The agreed interference computation program should rely extensively on existing ITU-R Recommendations.

3.1.2 Bilateral coordination/registration

This section provides a description for the case of an operator wanting to deploy a receive FSS earth station in country A and wanting to address the potential interference that a transmit FS station in another country can cause to this earth station.

One possible path for this operator to follow is to request its administration to conduct coordination and registration of this earth station as prescribed in the RR (see § 3.1.3 of this Annex).

Another possible path calls for the establishment of bilateral agreements between the administration of country A and the administrations of those countries with whom ITU coordination is triggered.

For instance, if country B is one of these countries, A and B would implement a bilateral agreement that basically prescribes that deployment of receive FSS earth stations in country A and of transmit FS stations in country B should follow the steps of the simplified coordination/registration described in § 3.1.1 of this Annex. In this case, the database of FSS earth stations and FS stations would be common to countries A and B (or at least be available to both countries) and the interference computation program would have to be agreed between countries A and B.

In order for receive FSS earth stations to be deployed in country A according to this simplified coordination/registration approach, bilateral agreements with several countries may be required. For most receive FSS earth station locations it would be expected that only one of these bilateral agreements would have to be used, although more than one agreement might have to be used for some specific earth station locations within country A.

3.1.3 Coordination/registration according to RR provisions

If country A has established bilateral agreements with all countries that have FS transmit stations with the potential of causing interference to FSS receive earth stations in country A, there is no need for ITU registration of receive FSS earth stations deployed in country A. However, if country A so wishes, this registration could still be done.

The assumption here is that a country that would have to be involved in the ITU coordination of a specific receive FSS earth station in country A already has a bilateral agreement addressing such coordination with country A.

3.2 Deployment of transmit FSS earth stations in country "A"

3.2.1 Individual country coordination/registration

This section provides an example of simplified coordination/registration for the case where FS stations exist in country A, and that administration wishes to ensure protection of existing receive FS stations from its transmitting FSS earth stations. This case also includes four steps:

Step 1: Identification of potentially affected FS receive stations: In this step the FSS operator relies on a particular administration's database containing details (see Annex 2) of receive FS stations and uses a pre-agreed interference computation program to determine whether there is potential for causing unacceptable interference from its proposed FSS earth station to any of the FS receive stations in the database.

Step 2: Detailed coordination, if required: If it is concluded that the transmit FSS earth station will not cause unacceptable interference to the FS stations in the database, this earth station can be deployed; otherwise, detailed coordination with the potentially affected receive FS station operators is required.

Step 3: Registration of the new FSS earth station: Registration of the new FSS earth station (i.e. addition of this earth station to the national database of transmit earth stations) in order to ensure that future FS stations will take it into consideration in order to ensure their own protection can only occur upon successfully completing the agreed interference computation program, or upon successful conclusion of detailed coordination.

Step 4: Future protection of receive FS stations: If, relying on the database containing the transmit FSS earth stations, an FS operator finds, upon applying the agreed interference computation program or other desired interference analysis tools, that potential unacceptable interference may be caused to the proposed installation, then detailed coordination with the operator(s) of the potentially interfering transmit FSS earth station(s) must be conducted. Registration of the new FS station (i.e. addition of this station to the national database of receive stations) in order to ensure that future transmit FSS stations will take it into consideration can only occur upon successfully completing the agreed interference computation program, or upon successful conclusion of detailed coordination.

Observations very similar to those presented in § 3.1.1 of this Annex are also applicable to this case. In particular, reliable databases (containing appropriate details of all transmit FSS earth stations and receive FS stations in the band under consideration), and a pre-agreed interference computation program to determine whether the transmit FSS earth station can be deployed, are essential for implementing the simplified coordination/registration process proposed here.

3.2.2 Bilateral coordination/registration

This section addresses the case of an operator wanting to deploy a transmit FSS earth station in country A and wanting to address the potential interference that this station can cause to a receive FS station in another country.

One possible path for this operator to follow is to request its administration to conduct coordination and registration of this earth station as prescribed in the RR (see § 3.2.3 of this Annex).

Another possible path calls for the establishment of bilateral agreements between the administration of country A and the administrations of those countries with whom ITU coordination is triggered.

For instance, if country B is one of these countries, A and B would implement a bilateral agreement that basically prescribes that deployment of transmit FSS earth stations in country A and of receive FS stations in country B should follow the steps of the simplified coordination/registration described in § 3.2.1 of this Annex. In this case, the database of FSS earth stations and FS stations would be common to countries A and B (or at least be available to both countries) and the interference computation program would have to be agreed between countries A and B.

In order for transmit FSS earth stations to be deployed in country A according to this simplified coordination/registration approach, bilateral agreements with several countries may be required. For most transmit FSS earth station locations it would be expected that only one of these bilateral agreements would have to be used although more than one agreement might have to be used for some specific earth station locations within country A.

3.2.3 Coordination/registration according to RR provisions

If country A has established bilateral agreements with all countries with whom ITU coordination would possibly be triggered by transmit FSS earth stations in country A, there is no need for ITU registration of transmit FSS earth stations deployed in country A. However, if country A so wishes, this registration could still be done.

The assumption here is that a country that would have to be involved in the ITU coordination of a specific transmit FSS earth station in country A already has a bilateral agreement addressing such coordination with country A.

It is noted that the simplified coordination/registration procedure described in § 3.2.1 of this Annex addresses a "specific" transmit FSS earth station since earth stations are added one by one to the database containing the transmit FSS earth stations in country A. This means that, under the scenario considered in this section, if country A chooses to register transmit earth stations with ITU, the current regime that only allows the registration of specific FSS earth stations would be suitable.

4 Summary

Table 1 summarizes the coordination/registration procedures described in § 3.1 and 3.2 of this Annex.

TABLE 1

Example coordination/registration methods for an FSS earth station in country A

		Deployment of receive FSS earth stations in country A	Deployment of transmit FSS earth stations in country A
National coordination -registration (Country A)	No FS in country A	No national coordination/registration required	
	FS in country A	– Coordination-registration relies on database of transmit FS stations and adds earth station to database of receive FSS earth stations. – Deployment of future transmit FS stations relies on receive FSS database and on an agreed interference computation program	– Coordination-registration relies on database of receive FS stations and an agreed interference computation program; adds earth station to database of transmit FSS earth stations. – Deployment of future receive FS stations relies on transmit FSS database
Bilateral coordination -registration (Countries A and B)	FSS earth station coordination area does not extend into country B	No coordination-registration required with respect to country B	
	FSS earth station coordination area extends into country B (ITU coordination required)	– Coordination-registration relies on database of transmit FS stations in country B and adds earth station to database of receive FSS earth stations in country A. – Deployment of future transmit FS stations in country B relies on country A receive FSS database and on an agreed interference computation program	– Coordination-registration relies on database of receive FS stations in country B and an agreed interference computation program; adds earth station to database of transmit FSS earth stations in country A. – Deployment of future receive FS stations in country B relies on country A transmit FSS database
International coordination -registration (Countries A and B)	FSS earth station coordination area does not extend into country B	– No coordination with country B required. – ITU registration does not depend on country B agreement	
	FSS earth station coordination area extends into country B (ITU coordination required)	– If bilateral coordination-registration agreement with country B is in place, ITU coordination-registration probably not necessary but, as far as country B is concerned, can be done promptly	

The example methodologies for coordination/registration described above can be used to reduce the national regulatory procedures that arise when a large number of FSS earth stations are to be deployed in a country where there is co-frequency FS deployment.

Even if a country chooses to deploy a large number of FSS earth stations and FS stations in separate spectrum, problems may arise from the need for coordination/registration of FSS earth stations vis-à-vis FS stations of neighbouring countries. These problems are localized (around borders) and are usually much less extensive than those stemming from the need for national coordination/registration of FSS earth stations. In any case, the methods described in this Annex for coordination/registration could be incorporated in a bilateral agreement.

Two key requirements for implementing these methods are the availability of a database of FSS earth stations and FS stations and an agreed interference computation program to be used to determine whether deployment of a transmit FS station or FSS earth station can be effected without causing unacceptable interference, respectively, to a receive FSS earth station or FS station. The database and agreed interference computation will have national or bilateral scope depending on whether national or bilateral coordination/registration is being addressed.

Attachment 1 to Annex 1

Example implementation of registration method

Below is a possible example, which may be considered by administrations of how the simplified registration process as described in § 3.1.1 of Annex 1 could be implemented. The satellite operator establishes the necessary arrangements with the agreement of the concerned organizations to facilitate the implementation of the following process.

Step 1: The end user of a terminal places an order for a satellite earth station at a specified location from a service provider.

Step 2: The service provider supplies the proposed location of the earth station to the satellite operator or its representative.

Step 3: The satellite operator (or representative) applies the simplified processes of § 3.1.1 and 3.2.1 of Annex 1 for the receive and transmit bands, respectively, of the proposed FSS earth station for the administration(s) concerned in order to determine whether the proposed FSS earth station can be successfully deployed:

– Note that it is clear that the success of this approach will be dependent on the maintenance and availability of accurate FS station and FSS earth station databases.

Step 4: If Step 3 is completed successfully the original order for the new FSS earth station is finalized and the service provider arranges for installation of the satellite terminal at the user specified location.

Step 5: The FS entity desiring to install a new FS link would search the FSS earth station database in the band shared with the FSS and would deploy at locations that would not cause unacceptable interference to registered satellite user earth stations. The agreed interference computation program would be used to determine a location for the FS link from where no unacceptable interference would be caused to registered earth stations. The FS user would not be required to protect non-registered satellite earth stations in shared spectrum.

Annex 2

Elements to be used in an agreed interference calculation

This Annex provides a description of the elements that should be included in an agreed interference calculation that may be used with the cases described in Annex 1 for the deployment of large numbers of FSS earth stations in bands shared with FS stations.

1 Objective

This methodology must have the capability of doing the following:

a) determining or establishing a database in a format compatible with software for both FS and FSS stations for the band in question;

b) building the database through incorporation of already existing, and subsequently deployed, earth stations or fixed stations;

c) adding new earth stations at specific locations and oriented toward an associated satellite orbital location on the basis of interference calculations (see d));

d) determining if a new FSS earth station would cause or suffer unacceptable interference to or from existing FS stations in the database before it is added to the database;

e) adding new FS stations at specific locations and oriented toward associated FSS earth stations on the basis of an interference calculation (see f));

f) determining if a new FS station would cause or suffer interference to or from existing FSS earth stations in the database before it is added to the database;

g) allowing alternative FSS earth station and FS station locations or orientations to be considered when it is determined that an initially proposed location or orientation would cause or suffer unacceptable interference into/from other FS stations or FSS earth stations, respectively.

It is noted that algorithms exist that can be adapted to such a simplified coordination method of large numbers of earth stations in shared FSS/FS bands.

2 System parameters

In order to apply a site-specific interference calculation methodology, a number of parameters for both the FS and FSS systems need to be available. The following sections summarize the critical parameters for a such a methodology.

2.1 FS

The FS transmit system parameters required for use in this methodology include:

– Antenna height (m) above mean sea level

– Antenna dish size (m)

– Antenna peak gain (dBi)

– Radiation pattern[1]

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[1] An appropriate radiation pattern should be used such as those in Recommendations ITU-R F.1245 or ITU-R F.1336.

– Path length (km)
– Location (latitude/longitude)
– Azimuth (degrees)
– Elevation (degrees)
– Specific operating frequency band (start/stop frequency (GHz))
– Unfaded *C*/*N* (dB)
– Tx power (dB(W/MHz)) at the input to the transmit antenna
– Effective receiver noise level (dB(W/MHz)) at output of receive antenna
– Threshold aggregate acceptable *I*/*N* (dB) at output of receive antenna
– FS receive antenna and site information.

2.2 FSS

The FSS earth station transmit system parameters required for use in this methodology include:

– Antenna height (m) above a mean sea level
– Antenna dish size (m)
– Antenna peak gain (dBi)
– Radiation pattern[2]
– Location (latitude/longitude)
– Azimuth (degrees)
– Elevation angle (degrees)
– Specific operating frequency band (start/stop frequency (GHz))
– Unfaded *C*/*N* (dB)
– Tx power (dB(W/MHz))
– Receive noise temperature (K)
– Threshold aggregate acceptable *I*/*N* (dB)
– FSS earth station receive antenna and site information.

3 Algorithm

The algorithm used in these calculations could consist of a basic interference calculation using *I*/*N* protection ratios for the FS and FSS stations, along with the system characteristics indicated in § 2 of this Annex.

If, after repeated applications of the algorithm, a suitable location or orientation of the FSS earth station or FS station cannot be found, then other factors can be considered. For example, by entering into detailed coordination with the potentially affected FS operator it may be determined whether any mitigation techniques could be applied to solve the problem.

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[2] An appropriate radiation pattern should be used such as that in Recommendation ITU-R S.465.

Annex 3

Example of development of a single coordination distance that could be applied in the case of coordination of large numbers of earth stations operating in the bands shared with the FS

1 Introduction

This Annex presents an example basis for considering the possibility of using a single transmit and single receive coordination distance to facilitate the coordination of large numbers of FSS earth stations. The Annex presents a parametric analysis of coordination distance calculation results, using the calculation methods of RR Appendix 7. This initial analysis was based upon Tables 7c and 8c of RR Appendix 7, This example addresses the FSS frequency bands around 20/30 GHz shared with the FS, but the same approach can be used for other FSS bands.

2 Analysis method

The RR Appendix 7 calculation methodology is used to develop this calculation. The method is dependent on certain local geographical information as well as the RF characteristics of the interfering and victim stations. The parameters used to perform the calculation for the frequencies concerned are listed in Table 2 along with the initial baseline values. Analyses were carried out to determine the sensitivity of the RR Appendix 7 methodology to variations in these input parameters. These are represented in cases 1-12 as indicated in Table 3. The values in each column indicate the parameter being varied for a particular case. The analyses are used to help identify a set of worst-case conditions and a corresponding maximum coordination distance.

TABLE 2

RR Appendix 7 parameters

Parameter	Units	Baseline
Geographic information		
Horizon distance	km	30
Horizon elevation angle	degrees	0
Earth station latitude	degrees	0
Radio climatic zone		A2
Distance to coast (Zone A1 only)	km	0
Aggregate land distance	km	100
Continuous inland distance	km	100
Continuous land distance	km	100
Rain zone		A
Space station inclination angle	degrees	0
Longitudinal difference	degrees	0

TABLE 2 (*end*)

Parameter	Units	Baseline
Earth station characteristics		
Transmit power	dB(W/Hz)	–58
Transmit gain	dBi	40
Receive gain	dBi	40
Receive noise temperature	K	120
Transmit frequency	GHz	27.5
Fixed station characteristics		
Transmit power	dB(W/1 MHz)	–5
Transmit gain	dBi	45
Receive gain	dBi	50
Transmit frequency	GHz	17.9

3 Results

Results of the parametric analysis described above are presented in Table 3. The coordination distance derived from the RR Appendix 7 methodology is shown for both transmit and receive earth stations over land and sea paths with variations in the input parameters. Some general observations for earth stations operating in the 20/30 GHz band can be made from these results:

– In general, the propagation mode (1) required distance is greater than that of mode (2).
– Paths over sea lead to greater required distances than paths over land.
– At the higher frequencies of the transmit earth station, the propagation loss at the minimum distance is, in general, sufficient to meet the protection requirements derived from RR Appendix 7.
– The required distance is greater for the receive earth station than for the transmit earth station.
– The required coordination distance is somewhat sensitive to the earth station latitude and the longitudinal separation between the earth and space stations.
– The coordination distance for the receive earth station is highly dependent on horizon elevation angle.
– Both the transmit and receive cases are relatively insensitive to most other geographic conditions.

Table 4 presents the results of a calculation of the coordination distance assuming a worst-case combination of input variables. This of course represents a situation in which all environmental conditions align in the most disadvantageous way and is unlikely to occur, but it is shown here to give an estimate of the upper bound for the required distance.

It should be noted that the RR Appendix 7 methodology provides a worst-case estimate of the required distance in that the FS station is assumed to point directly toward the earth station. Accounting for the actual pointing direction of the FS station will in most situations significantly reduce the coordination distance. Any agreed computational program developed as part of these simplified coordination procedures would need to take into account the FS station antenna orientation.

TABLE 3

Results of parametric analysis

Parameter	Units	Baseline	Case					
			1	2	3	4	5	6
Horizon distance	km	30						20:20:100
Horizon elevation angle	degrees	0			–2, –1, 1			
Earth station latitude	degrees	0	20, 40, 60					
Radio climatic zone		A2						
Distance to coast	km	100						
Aggregate land distance	km	100						
Continuous inland distance	km	100						
Continuous land distance	km	100						
Rain zone		A				A to H	J to Q	
Space station inclination angle	degrees	0						
Longitudinal separation	degrees	0		20, 40, 60				
Maximum coordination distance on land path								
Transmit earth station	km	110	100, 94, 92	111, 112, 116	110	110	110	110
Receive earth station	km	144	140, 135, 145	144, 144, 163	167, 162 114	144	144	144
Maximum coordination distance on sea path								
Transmit earth station	km	110	100, 94, 92	111, 112, 116	n/a	110	110	110
Receive earth station	km	162	160, 158, 176	162, 162, 184	n/a	162	162	162
Horizon distance	km	30						
Horizon elevation angle	degrees	0						
Earth station latitude	degrees	0						
Radio climatic zone		A2	A1 to C					

TABLE 3 (*end*)

Parameter	Units	Baseline	Case					
			1	2	3	4	5	6
Distance to coast	km	100		10, 1 000				
Aggregate land distance	km	100			10, 1 000			
Continuous inland distance	km	100				10, 1 000		
Continuous land distance	km	100					10, 1 000	
Rain zone		A						
Space station inclination angle	degrees	0						1 to 5
Longitudinal separation	degrees	0						
Maximum coordination distance on land path								
Transmit earth station	km	110	110	110	110	110	110	110
Receive earth station	km	144	144	146, 144	135, 149	149, 144	145, 144	144
Maximum coordination distance on sea path								
Transmit earth station	km	110	110	n/a	n/a	n/a	n/a	110
Receive earth station	km	162	162	n/a	n/a	n/a	n/a	162

n/a: not available.

TABLE 4

Worst-case coordination distance

Parameter	Units	Worst case
Horizon distance	km	20
Horizon elevation angle	degrees	–2
Earth station latitude	degrees	60
Radio climatic zone		A2
Distance to coast	km	100
Aggregate land distance	km	100
Continuous inland distance	km	100
Continuous land distance	km	100
Rain zone		A
Space station inclination angle	degrees	0
Longitudinal separation	degrees	60
Maximum coordination distance on land path		
Transmit earth station	km	116
Receive earth station	km	198
Maximum coordination distance on sea path		
Transmit earth station	km	137
Receive earth station	km	240

4 Conclusions

The example parametric analyses performed for the 20/30 GHz band indicate that it is possible to develop a single coordination distance which could be applied to the deployment of large numbers of FSS earth stations. The distance determined indicates a distance beyond which it would not be necessary to coordinate an earth station with another country. In this case the typical coordination distance is on the order of 110 km for transmit earth stations and 160 km for receive earth stations. The analysis also shows that at these frequencies, the coordination distance is relatively insensitive to most environmental conditions. The analyses provide an estimate of the upper bound for the required distance.

It is expected that there would be a reduction in the required coordination distance when taking account of the orientation of FS stations. When being considered as a single value for cross border coordination, it is expected that the coordination distance could be reduced by applying limits on the parameters used for worst case.